PATENT SPECIFICATION

1,195,288

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Capacity Sensing Means for Automatic Flushing Systems and the like

We, WAGNER ELECTRIC CORPORATION, a corporation of the State of Delaware, United States of America, having its offices at 1 Summer Avenue, Newark, New Jersey, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to automatic devices which include flush valves in sanitary systems.

The automatic operation of flushing valves in urinals and other sanitary facilities is desirable for many reasons. Some automatic systems have used a conductive plate mounted above the facility to sense the presence of a person by the added capacity formed by the persons body. This arrangement works well for adults but somctimes fails to work when the facility is used by short people. An object of the present invention is to provide an improved capacity sensing for use in such automatic devices.

According to the invention, there is provided a capacitance-responsive circuit for controlling energisation and de-energisation of a load, said circuit including first and second capacitances, an antenna system comprising a single, electrically conductive antenna member forming both a first plate of said first capacitance and a first plate of said second capacitance, said antenna member being positioned to co-operate with an object moving into and out of a predetermined range of proximity thereto, said object forming a second plate of said first capacitance and causing variations in said first capacitance, wherein said antenna system further comprises an electrically conductive shielding member positioned in relation to said antenna member so as to electrically interrupt flux lines from said antenna member to earthed elements in proximity to said antenna, said antenna, said shielding member forming a second plate of said second capacitance the shielding member being positioned entirely behind the antenna member in relation to the object to be detected and in use, said shielding member being at a non-zero potential.

A second conductive element may be a plate enclosed within a wall or a partition which separates one facility from another.

In the accompanying drawings:

Figure 1 is a schematic diagram of connections showing how the sensing screen is coupled to a pair of output terminals which may be connected to a flush valve or to a motor which operates a flush valve,

Figure 2 is a schematic diagram of connections of an alternate coupling means where the circuit components are mounted some distance from the sensing means,

Figure 3 is an isometric view of one type of urinal employing an alternate type of capacity sensing means,

Figure 4 is a top view of the facility shown in Figure 3,

Figure 5 is a cross-sectional view of the facility shown in Figure 3 and is taken along line 5—5 of that Figure, and

Figure 6 is a schematic diagram of connections showing two alternate schemes of connection to balance the capacity effects introduced by a grounded water curtain in the facility.

Referring now to Figure 1, the system of the present invention includes a flat plate 10 which is mounted alongside the position where a user may stand. The plate may be quite extensive and have dimensions two feet wide by four feet high. A conductive screen 11 is mounted parallel to the plate 10 and may be set about one-half inch from the plate. This sensing device includes a distributed capacity 12 between the screen 11 and earth which in this case may be the floor or the usual plumbing fixtures which are conductive. When a person stands before the facility his body also forms a capacity 13 between the screen and

earth and it is this added capacity that operates the circuit and causes the valve to flush after the person leaves the facility.

A mesh has been indicated in Figures 1 and 2 because this type of electrode is convenient to use and because it covers a large area. However, many other types of electrodes may be used. Several small plates, a plurality of rods mounted either horizontally or vertically, serve the purpose equally well.

An oscillator circuit is connected to the plate 10 and the screen 11, this oscillating circuit including a small neon lamp 14 and also two resistors 15 and 16 which are connected in series between the plate 10 and an earth connection. One of the lamp electrodes is connected to an adjustable contact 17 which slides on a resistor 18 connected between resistors 15 and 16. Resistor 18 may be bridged by an additional resistor 20, but this is not always necessary. The other terminal of the lamp 14 is connected to the screen 11. The screen 11 is also connected to a conductor 21 in series with a limiting resistor 22. The conductor 21 is connected to a source of negative potential which in this case is furnished by a diode 23 and a capacitor 24. These components are connected to power supply terminals 25 and 26 which are to be connected to an alternating current power system of about 117 volts. The system of connections described above is an oscillator and includes a first capacity 19 between the plate 10 and the screen 11. A second capacity 12 is formed between the screen 11 and earth. Both these capacitors are charged when conductor 21 is supplied with a negative potential. As the charge is applied through resistor 22, the voltage across the lamp terminals increases until the firing voltage is reached, then the lamp conducts and the potential across its terminals is reduced below the lamp sustaining potential. This action allows capacitor 19 to discharge to produce a current pulse in resistor 15 which moves in the direction of arrow 27. The discharge of capacitor 12 produces a similar current pulse in resistor 16 but in an opposite direction as indicated by arrow 28. If resistors 15 and 16 are equal and if capacities 12 and 19 are equal, there will be no alternating voltage applied across the end terminals of resistors 15 and 16.

When a person steps up to the urinal, an added capacity 13 is connected between the screen 11 and an earth conductor 30. This causes the oscillator to present an unbalanced series of pulses to resistors 15 and 16. In this case, the pulses through resistor 16 will be greater than the pulses applied to resistor 15 and a negative voltage will be applied to the upper end of resistor 15. There may be a wide variety of coupling circuits connected between resistors 15 and 16 and an output set of terminals 31 and 32 which are to be connected to a load circuit. The coupling circuit described herein comprises two transistor amplifiers 33 and 34, a semiconductor switching circuit 35, a first relay 36 and a second relay 37. These major components are interconnected so as to provide a very definite programme of operations.

The first amplifier, transistor 33, has its emitter connected in series with a resistor 38 to the earth conductor 30. The emitter is also coupled to the base of transistor 34 through a capacitor 40. The collector of transistor 33 is connected to a voltage divider which includes resistors 41 and 42. The base of transistor 34 is connected to a voltage divider which includes resistors 43 and 44 on one side and resistor 45 on the earth side, thereby partially stabilising the voltage on the base. The emitter of transistor 34 is connected directly to the earth conductor 30 while the collector is connected in series with resistor 43 to the negative conductor 21. The collector of transistor 34 is coupled through a small capacitor 46 to a double transistor switching means 35. This switch includes a p-n-p transistor 47 having its emitter connected to the alternating current supply in series with a resistor 48. The n-p-n transistor 50 has its emitter connected to the earth conductor 30. This switching combination has the base of each transistor connected to the collector electrode of the other transistor with the base of transistor 50 connected to the coupling capacitor 46. The base of transistor 50 is also connected to an automatic bias circuit including a resistor 29 and a capacitor 39. This circuit has been described in our co-pending British Patent Application No. 22647/67, (Patent No. 1,128,695). Negative pulses from supply line 21 connected to terminal 25 leak through the emitter-collector electrodes of transistor 50 and charge capacitor 39. The charge on this capacitor builds up until the breakdown voltage of transistor 50 is reached. Additional charge leaks to earth via earthed conductor 30.

The output of the double transistor switch means 35 is coupled through a diode 51 to a winding 52 of relay 36. The winding is shunted by a large capacitor 53 so that it may operate on discrete pulses without causing the armature to chatter. The armature of relay 36 is connected directly to terminal 25 of the alternating current supply. When the relay is not actuated, an upper set of contacts 54 is closed, thereby sending current through a resistor 55 and a lamp 56. When the relay is actuated, a lower set of contacts 57 is closed and alternating current is applied to conductor 58 which is connected to the collector electrode of a transistor 60 and through a diode 61 to the winding 62 of the second relay 37. This relay winding is also shunted by a large capacitor 63 so that it may operate without chattering when discrete pulses are applied to the winding.

Relay 37 also includes an armature connected directly to terminal 25 of the alternating

current supply. When the relay is actuated the normally open contacts 64 are closed and terminal 25 of the supply is then connected to terminal 31 of the load circuit. At the same time, the alternating current supply is connected by means of conductor 65 to winding 52 in series with a limiting resistor 66 and a diode 67.

Transistor 60 has its collector connected directly to conductor 58 and its base is coupled to a delay circuit 68 which includes a first capacitor 70 and a second capacitor 71. Capacitor 70 is connected across resistors 72, 73 and 74, these resistors being connected in series with each other. Capacitor 71 is connected across resistors 73 and 74. A diode 75 is connected between line 58 and the junction of capacitor 70 with resistor 72. The purpose of this delay circuit will be described later.

The operation of this circuit is as follows:

It is evident that the oscillator circuit which includes lamp 14 and the chargeable capacitors, oscillates all the time, starting as soon as the negative voltage is applied to conductor 21. When there is no person adjacent screen 11, there is substantially no output applied to the base of transistor 33 because the output voltages are balanced. No pulses are applied to transistor 34 and no pulses are applied to the semiconductor switch 35, therefore the switch is not conductive and the first relay 36 receives current through resistor 48 and diode 51 so that it is actuated and the armature is pulled down closing contacts 57 as shown in the drawing. The lamp 56 is not lighted but current is applied to conductor 58 and to the delay circuit 68. Negative current pulses now flow through diode 75 to charge capacitor 70 to about 150 volts and to charge capacitor 71 to about 40 volts. Since the base of transistor 60 is connected to the mid-point of resistors 73 and 74, its base is maintained at a slight forward potential, transistor 60 is conductive and by-passes current around winding 62 of relay 37, and contacts 64 remain open. The values of resistors 72, 73 and 74 and of capacitors 70 and 71 are arranged so that it takes about five seconds for these capacitors to charge to a negative voltage which applies a small negative voltage to the base of transistor 60 and thereby shunts the current around winding 62 and permits contacts 64 to open and cut off the voltage to the load terminals. This five seconds time interval is chosen because it takes about five seconds for the flushing operation. It is obvious that any time interval can be produced by such a circuit to accommodate other desired operations.

Now let it be assumed that a person steps up to the sanitary facility and the capacity of his body is added to the capacity 12 which normally exists between the screen and earth. This added capacity, which may be only 3 picofarads, causes considerable change in the oscillating circuit and the current through resistor 15 is considerably less than the current through resistor 16. Negative pulses are thereby applied to the first transistor base and these pulses are amplified and negative pulses are applied through capacitor 40 to the base of the second transistor 34. This produces amplified positive pulses which are applied through capacitor 46 to the switch combination, causing it to conduct and short circuit the winding 52 of relay 36, thereby opening contacts 57 and closing contacts 54. This action removes the alternating current voltage from conductor 58 and lights lamp 56.

When voltage is removed from conductor 58, capacitors 70 and 71 discharge through resistors 72, 73 and 74 in about twelve seconds and apply a more positive voltage to the base of transistor 60 to make it non-conductive. However, current cannot be applied to winding 62 of relay 37 because contacts 57 are open and therefore contacts 64 remain open and the load is not energised. As long as the first relay 36 is unactuated, the second relay cannot operate. This means that as long as the person stands adjacent to screen 11, the load is not actuated and there is no flushing operation.

Now let it be assumed that the person leaves the facility and thereby removes the added capacity 13 and restores the oscillating system to its normal condition. Now there is no voltage applied to the transistor switch 35, the switch is non-conductive, and the first relay winding 52 receives current, thereby turning off lamp 56 and applying alternating current voltage to conductor 58 and negative pulses to winding 62, thereby operating the relay and closing contacts 64. The load is now supplied with power and the flushing motor (not shown) is actuated causing a flushing operation. The motor continues to operate for about five seconds until capacitors 70 and 71 are charged to a voltage which applies a negative 20-volt bias to the base of transistor 60. This causes the transistor to conduct and short current away from winding 62 to open contact 64 and cut off current to the motor.

The above circuit could be operated to flush prematurely if the person stepped away and then returned within five seconds. If this happened, the double transistor switch would then be conditioned to pass current and normalise the first relay. In order to make sure that this does not occur, an additional circuit is provided. This circuit includes conductor 65, resistor 66, and diode 67. As long as contacts 64 are closed, current is supplied from terminal 25 through contacts 64, over conductor 65 and diode 67, to relay winding 52, thereby maintaining contacts 57 closed regardless of the condition of switch combination 35. This permits the load motor to continue working for the allotted five seconds to complete the flushing operation. This interlocking circuit guards against flooding due to the person moving

about. Also, a second person may step up to the facility within seventeen seconds without causing premature operation. If there were no interlock circuit, flushing could start again and cause undesirable wetting.

The circuit shown in Figure 2 is an alternate arrangement of the sensing means. It is the same as the sensing means shown in Figure 1 except that a conductive concentric cable 76 is used to shield the conductor 77 which connects the screen 11 to one terminal of the lamp 14. The outer conductor 78 is connected to the plate 10 at one end and to the base of the transistor 33 at the other end. This type of connection may be necessary when the operating circuitry must be mounted some distance from the sensing plate and screen. The effect of the addition is to increase the capacity between the plate and the screen. The charging current and the discharge current are both increased but the circuit can easily be re-balanced by a shift of contact point 17 or by altering either of resistors 15 or 16. The operation of such a circuit is the same as the circuit shown in Figure 1.

Referring now to Figures 3, 4, 5 and 6, there is shown an alternate facility 80, made of porcelain or similar material and having a flat back portion and extending side portions 81 and 82. This shape makes possible an alternate array of capacity sensing electrodes enclosed in the facility and not visible to the user. A solid conductive back plate 10A (corresponding to plate 10 in Figure 1) forms a part of the sensing system and compensates for the presence of an earthed water curtain 91. Two conductive rods 83 and 84 take the place of the mesh in Figure 1. The conductive element formed by rods 83 and 84 has an area less than one half of the conductive plate 10A. Because of the positions of these sensing electrodes, it is necessary to make allowance for the water curtain 91 which may be present during the use of the facility. Since the water flows into a metal drain pipe, the curtain is earthed and a considerable capacity is thereby introduced between the shield and earth. An additional capacity 92 is introduced between the water curtain and the rods 83 and 84. The distributed capacities between the rods and earth are shown in Figure 6 as capacities 85 and 86.

In most installations of this type, the control circuit should be mounted at a distance from the facility where it cannot be wetted and where it is difficult for a user to harm it. Such an installation generally calls for a shielded cable 76 as shown in Figures 2 and 6, having a central conductor 77. A small distributed capacity is always present in such a line and this capacity is made a part of the oscillation circuit by connecting the discharge lamp 14 between the concentric conductor 77 and the mid-point between the two resistors 15 and 16. When the lamp 14 discharges, part of the current pulse travels over conductors 87 and 77 to rods 83 and 84, through distributed capacities 85 and 86, to the earthed conductor 30, resistor 16, to the other side of the lamp 14. Another portion of the discharge travels over conductors 87 and 77, then through the cable capacity 88, to conductor 90, resistor 15, and the other side of the lamp. If these were the only discharge paths, an adjustment of resistor 16 can be made to balance the voltage drops and the output (with no person near the rods) would be substantially zero.

The water curtain 91 is sometimes present and is always earthed. There is a definite small capacity 92 between the sensing rods 83, 84 and the water curtain 91. When this capacity increases, the discharge pulses from the lamp 14, over conductor 77, increase and the voltage drop across resistor 16 increases, thereby increasing the output signal. This capacity 92 shunts capacities 85 and 86 and tends to lower the sensitivity. This defect may be partially compensated by placing the shield 10A directly behind the water curtain to introduce a larger capacity between the shield and earth. When switch 94 is moved to its upper position as shown in Figure 6, capacity 93 shunts a portion of the discharge current which would normally travel through resistor 15 from the cable covering, through capacity 93, to the earth conductor and resistor 16.

The presence of a man, represented by capacity 13, increases the discharge current through resistor 16 and causes an unbalance voltage which is amplified and utilised in the manner explained above in connection with Figure 1.

Another type of compensation may be obtained by connecting the switch blade 94 to its lower terminal. Then one portion of the discharge current from the lamp passes through the cable, over conductor 77 to the sensing rods 83 and 84, through capacitors 92 and 93 to a portion of resistor 16 and to the other side of the lamp. Resistor 15 may be adjusted so that there is no output when there is no capacity 13 (man) in front of the rods. When capacity 13 is added, the discharge current flowing through the lower part of resistor 16 provides the desired unbalance voltage and an output signal is produced.

It will be obvious that the above system of components can be adjusted to produce either a positive or a negative system of discharge pulses. If such a change is made, the number of amplifying stages may be changed to produce the same signal for the load coupling circuit.

A highly important feature of the present invention comprises the use of the energized shielding members 10 in Figures 1 and 2, and 10a in Figure 6, in association with the antenna members 11 in Figures 1 and 2, and 83 and 84 in Figure 6. If such shielding members were not used, the residual (no-signal) capaci-

tance to ground of the antenna members 11, 83 and 84 alone would be quite large, on the order of 80 to 100 picofarads, due to the unavoidable close proximity of these antenna members to grounded elements of the urinal or sanitary facility in which the antenna members are installed, e.g. water pipes and flush valves. The increment of capacitance to ground added by the person using the facility is only 1 picofarad or less. Thus, the change in the capacitance to ground of the antenna members alone caused by the presence of the person using the facility would amount to only one or two percent maximum, and such a small signal would cause such severe problems of poor sensitivity and stability as to make the device virtually impractical.

The shielding members 10 and 10*a* are physically interposed between the antenna members 11, 83 and 84 and the ground elements of the santitary facility and are driven by application of a potential from the associated circuit, and thereby interrupt flux lines between the antenna members and the grounded elements of the sanitary facility to reduce the residual capacitance to ground of the antenna members to about 15 to 20 picofarads. In this way, the small increment of capacitance added by the body of the person using the facility is made to represent a greater percentage of the residual capacitance of the antenna members to ground to provide a stronger signal which increases the sensitivity and stability of the associated circuit. It is true that there will be a large added capacitance to ground of the shielding members 10 and 10*a*. However, these capacitances are remote from the detection zone in which the antenna members are operative to sense the added capacitance of the user's body, and thus such added capacitances will not interfere with the necessary detection by the antenna members of the presence of the person in the position for use of the sanitary facility. Moreover, the capacitance between the antenna members 11, 83, and 84 and the shielding members 10 and 10*a* can be relatively large without causing any disadvantage or problems since these capacitances remain fixed and are connected to the associated circuit and can be compensated for or balanced by adjustment of other circuit components such as resistors 15, 16, 18 and 20. Accordingly, the use of shielding members interposed between the antenna members and nearby grounded elements and energized by application of a potential to reduce the residual capacity to ground of the antenna members provides substantial advantages and benefits in the invention and makes the disclosed device for control of sanitary facilities commercially practical.

WHAT WE CLAIM IS:—

1. In a capacitance-responsive circuit for controlling energisation and de-energisation of a load, said circuit including first and second capacitances, an antenna system comprising a single, electrically conductive antenna member forming both a first plate of said first capacitance and a first plate of said second capacitance, said antenna member being positioned to co-operate with an object moving into and out of a predetermined range of proximity thereto, said object forming a second plate of said first capacitance and causing variations in said first capacitance, wherein said antenna system further comprises an electrically conductive shielding member positioned in relation to said antenna member so as to electrically interrupt flux lines from said antenna member to earthed elements in proximity to said antenna, said shielding member forming a second plate of said second capacitance the shielding member being positioned entirely behind the antenna member in relation to the object to be detected and in use, said shielding member being at a non-zero potential.

2. An antenna system as claimed in claim 1, further comprising means for energising said shielding member by application of electric potential thereto.

3. An antenna system as claimed in claim 2, further comprising a coaxial cable having an inner conductor and an outer conductor, said inner conductor being electrically connected to said antenna member and said outer conductor being electrically connected to said shielding member, said coaxial cable forming an increment of said second capacitance and serving to connect said antenna member and said shielding member to the remainder of said capacitance-responsive circuit.

4. An antenna system as claimed in claim 1, further comprising a second electrically conductive member forming a second plate of said second capacitance, a coaxial cable having an inner conductor and an outer conductor said inner conductor being electrically connected to said antenna member and said outer conductor being electrically connect to said second member, said coaxial cable forming an increment of said second capacitance and serving to connect said antenna member and said second member to the remainder of said capacitance-responsive circuit.

5. An antenna system, substantially as described with reference to the accompanying drawings.

6. Capacity sensing means for detecting the presence of an object, said means comprising a conductive plate, a first conductive element mounted in spaced relation to said plate and insulated therefrom to establish a substantially fixed first capacity therebetween; said conductive element having an area less than one-half of the area of the conductive plate, an earthed conductor spaced from the element and defining a space in which the presence of said object is to be detected, said element being positioned to establish in the absence of an object to be detected a substantially fixed sec-

ond capacity between it and the earthed conductor; a source of alternating current electric power connected directly to said element and coupled through impedances to the earthed conductor and to the conductive plate for charging said capacities between the plate, the element, and earth; said impedances being connected so as to produce substantially no signal when an object is not present in said defined space, but producing an electrical signal when an object to be detected is in said defined space and thereby changing the capacity between the conductive element and earth.

7. A sensing means as claimed in claim 6, wherein the said signal is applied through an amplifier system to a first switching means to effect energisation of a timing circuit.

8. A sensing means as claimed in claim 7, further including a timing circuit for de-actuating a load-controlling relay after a predetermined period of actuation.

9. A sensing means as claimed in claim 8, wherein a locking circuit is provided for preventing de-actuation of the load-controlling relay during the predetermined period of actuation.

10. A sensing means as claimed in claim 9, wherein the load-controlling relay operates a pair of contacts which connect the load to an alternating current power supply, the locking circuit including a connection in series with a rectifying diode which connects one of the load contacts to an actuation circuit to maintain the power supply connected to the load for the predetermined period of actuation.

11. A sensing means as claimed in claim 6, comprising an oscillator including a voltage breakdown means having one terminal connected to the first conductive element by means of the inner conductor of a coaxial cable and the other terminal of the voltage breakdown means connected to a tapping point of a first circuit, one end of which first circuit is connected to the earthed conductor, the other end of the first circuit being connected to the outer conductor of the coaxial cable and to the conductive plate, the first circuit providing two current paths for the oscillator currents, one of the paths including said first capacity and a first resistor, the other path including said second capacity and the capacity created by the coaxial cable, and a second resistor arranged so as to produce substantially nill voltage between a pair of points in the first circuit when an object is not present, but to produce an electrical signal between said pair of points when an object is adjacent to the first conductive element and thereby adds additional capacity to the capacity between the first conductive element and the earth.

12. A sensing means as claimed in claim 11, wherein the oscillator is a relaxation oscillator and the voltage break-down means is a gas-filled lamp.

13. A sensing means as claimed in claim 11, wherein the first circuit is connected to a locking circuit, the output terminals of which are connected to a second circuit which controls the energisation and de-engisation of a load-controlling relay.

14. A sensing means as claimed in claim 11, wherein the second conductive element is a conductive plate positioned adjacent an earthed water curtain, thereby creating a capacity therebetween, the said capacity acting to divert part of the current flowing through the second capacitor to the earthed conductor.

15. A sensing means as claimed in claim 11, wherein the said conductive plate is connected to a tapping point in the second resistor.

16. A capacity sensing means, substantially as described with reference to the accompanying drawings.

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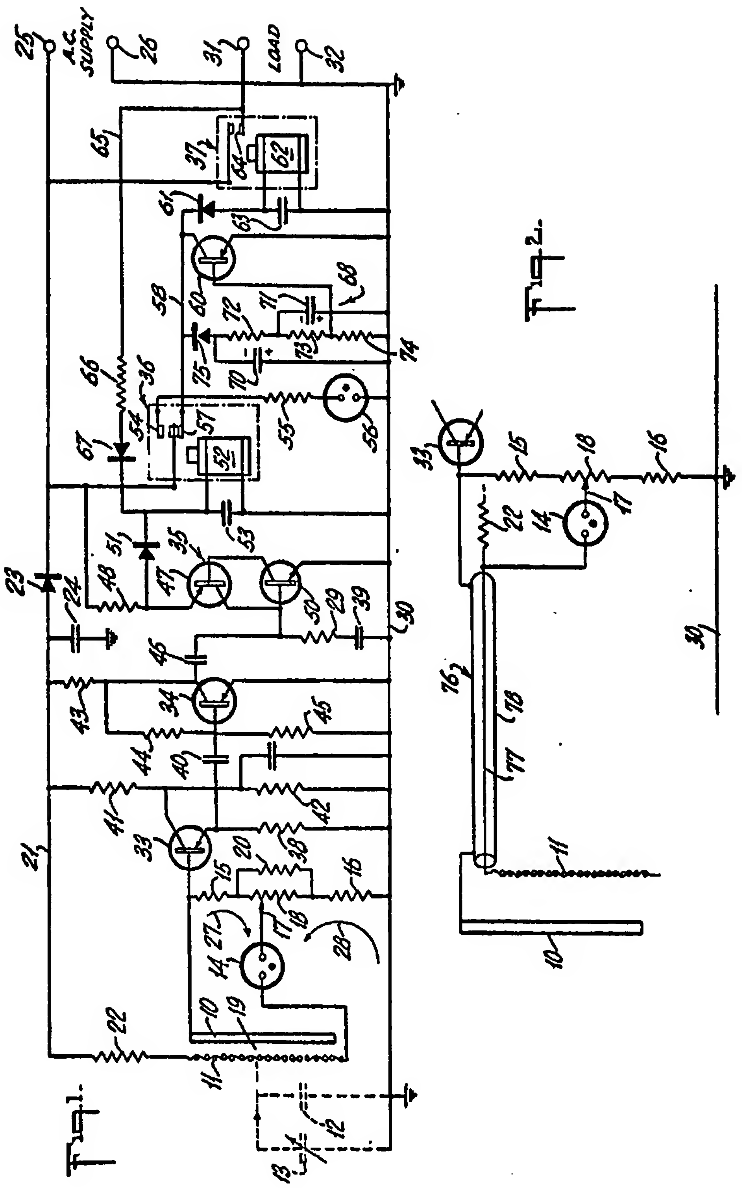
1195288 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1



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2 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 2

Fig. 3.

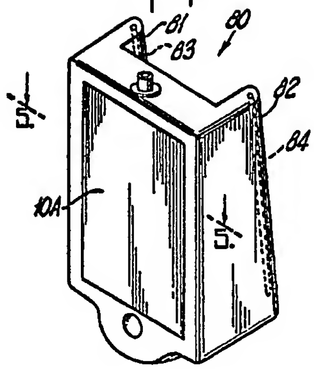

Fig. 4.

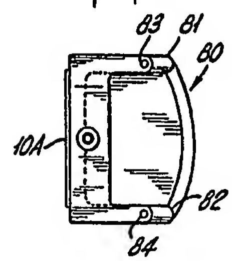

Fig. 5.

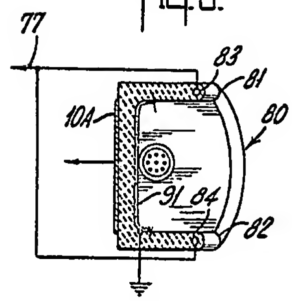

Fig. 6.